BYTHOTREPHES CEDERSTROEMI

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FIRST RECORDS OF THE EUROPEAN INVADER IN INLAND LAKES IN CANADA

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ABSTRACT

The presence of the European invader *Bythotrephes cederstroemi* is documented in the plankton of eight large, recreational lakes in south-central Ontario, Canada - Lake Muskoka, Lake Joseph, Lake Rosseau, Fairy Lake, Mary Lake, Peninsula Lake, Lake Vernon and Go Home Lake. These observations represent the first evidence that *B. cederstroemi* has invaded inland lakes in Canada.

INTRODUCTION

Bythotrephes cederstroemi Schoedler (Cercopagidae, Onychopoda) is a large, predaceous, Palearctic zooplankter that invaded each of the Laurentian Great Lakes during the 1980's (Bur et al. 1986; Lange and Cap 1986; Lehman 1987; Evans 1988; Cullis and Johnson 1988). In Europe, *Bythotrephes* inhabits lakes that range widely in size, depth, hardness, acidity, colour, nutrient status, and fish assemblages (Nilsson and Pejler 1973; Hobæk and Raddum 1980; Næsje et al. 1987). Therefore, it is safe to assume that the majority of inland lakes in temperate North America offer suitable habitat to the invader. There was no evidence that *B. cederstroemi* has colonized any inland lake in Canada, despite the availability of habitat. It is our purpose to report the presence of *B. cederstroemi* in eight of the twelve largest lakes in the Moon River/Go Home River watershed in the District of Muskoka in central Ontario, Canada.

STUDY LAKES

The twelve study lakes (Table 1) are located in the Moon River/Go Home River Watershed, tertiary watershed number 2EB of Cox (1978). The lakes are all large (Table 1). They have soft waters (range in conductivity of 30-69 µS at 20°C), and are circumneutral in reaction, suffering little from the impacts of acid precipitation (pH of 6.7-7.4, Gran alkalinity of 60-220 µeq/L). They are

oligotrophic, with total phosphorus levels genrally <10 mg/m^3, and nitrogen/phosphorus ratios >30 by weight. Reid and Girard (1988) and Yan et al. (1991) provide additional information on the morphometry, water chemistry, and physical limnology of the lakes.

The lakes are a very valuable resource in central Ontario. They are used for recreation by thousands of cottagers each summer (Table 1). They supply the drinking water for and receive domestic waste water from three towns with about 10,000 permanent residents (Huntsville, Bracebridge and Gravenhurst), and from several smaller villages.

METHODS

Two sampling methods were employed routinely, one on Lakes Joseph, Muskoka, and Rosseau, and a second on the remaining lakes. Zooplankton were collected from several widely-spaced stations in Lake Joseph, Lake Muskoka, and Lake Rosseau on a monthly shedule over the ice-free seasons of 1989 and 1990 (Table 1). At each station, triplicate vertical hauls from 0.5 m above the sediments to the lake surface were taken with either an 11.5 cm or a 13 cm diameter, non-metered conical tow net constructed of 76 μm mesh. The contents of the three hauls were pooled prior to enumeration. Volumes of samples were calculated assuming 100% filtration efficiency.

Zooplankton were collected from the remaining lakes in vertical hauls with a metered, 46 cm diameter, conical tow net constructed of 150 μm mesh. Hauls were taken through 30 m at stations deeper than 30 m, and from 2 m above the bottom at shallower stations. Occasionally, zooplankton were also collected in horizontal hauls using either the 46 cm diameter net, or a 47.5 cm diameter, metered, closing tow net constructed of 500 μm mesh. Samples were collected at several widely-spaced stations in each lake (Table 1) in July or August of 1990 and/or in June of 1991. Measured filtration efficiencies, used to calculate volumes of lakewater sampled, averaged 59.8%. Yan et al. (1991) provide maps showing all sampling locations.

B. Hutchinson (Ontario Ministry of the Environment) provided us with zooplankton samples she had collected as metered vertical net hauls from 14 stations in Lake Rosseau on July 27, 1983, 15 stations from Lake Muskoka on July 31, 1984, and from 12 stations in Lake Joseph on August 8, 1984. To our knowledge, no historical samples from the other study lakes exist.

All samples were preserved in the field with a 4% sucrose formalin solution. They were subsequently examined in their entirety for *B. cederstroemi*.

RESULTS

B. cederstroemi was not detected in any of the samples collected by Hutchinson from Lakes Muskoka, Rosseau and Joseph in 1983 and 1984, nor was it present in the 1969 collections of Michalski et al. (1973). In 1989 and 1990, *B. cederstroemi* was present in all three of these lakes. In the 1989 collections from Lake Muskoka, it was recorded in almost one-third of the 45 collections, and in four of the five months of sampling. In the 1990 collections from Lake Rosseau, it was recorded in all of the monthly sampling runs (Table 1).

B. cederstroemi was recorded in the 1990 collections from Fairy and Mary Lakes, but not in the six remaining lakes sampled in that year. Its absence from Lake Vernon and Peninsula Lake was a bit surprising because these lakes are connected with Fairy Lake by broad, flat channels. In the spring of 1991, *B. cederstroemi* was collected in horizontal hauls at the lake surface in both Lake Vernon and in Peninsula Lake. Two animals were also collected at the last of five stations visited in Go Home Lake, downstream of Lake Muskoka (Table 1).

In summary, the presence of *B. cederstroemi* is confirmed in eight of twelve large lakes sampled in the watershed - Go Home Lake, Lake Muskoka, Lake Rosseau, Lake Joseph, Mary Lake, Fairy Lake, Peninsula Lake and Lake Vernon. *B. cederstroemi* were not collected

in Skeleton Lake, Three Mile Lake, Lake of Bays or Kawagama Lake. Either the invader was not present in these lakes, or it was present at densities below our limits of detection. These limits can be approximated from the summed sample volumes to be 0.2, 0.67, 0.053, or 0.08 animals m^{-3}, respectively, for these lakes.

DISCUSSION

B. cederstroemi has been observed in only one other set of inland lakes in North America. Jeff Schuldt and Glen Merrick (University of Minnesota at Duluth, personal communication) collected *B. cederstroemi* in plankton hauls in Fish Lake, Boulder Lake, and Island Lake, three lakes in the Cloquete River watershed in northern Minnesota, U.S.A., in September, 1990. They suspected that *B. cederstroemi* had been introduced into these lakes by fisherman.

Fisherman may also have introduced *B. cederstroemi* into the Muskoka Lakes. We asked operators of marinas on Lake of Bays, Lake Muskoka, Lake Rosseau, Lake Joseph, and Fairy Lake if boats are moved from the Great Lakes into their lakes. They confirmed that such movement does occasionally occur. They also indicated that boats are frequently moved among our study lakes. This should speed the dispersal of *B. cederstroemi* within the watershed, now that it is established. There are 2022 lakes > 1 ha in this watershed (Cox 1978).

Of course we can not be certain how *B. cederstroemi* invaded the Muskoka lakes. The lakes are all isolated from Georgian Bay by several waterfalls and rapids; hence, colonizers could not have entered the lakes directly. In addition to boaters or fisherman, waterfowl may have served as the vector of colonization. It would be a short flight for migrating waterfowl from Georgian Bay to any of the colonized lakes.

At the moment we do not know how, or even if, the pelagic food webs of the Muskoka lakes will respond to the presence of *B. cederstroemi*. The European literature provides little guidance, because the consumption rates of *B. cederstroemi* have not been compared with the production rates of its prey in any European lake. The impacts of the invader on the plankton assemblages of the Laurentian Great Lakes are also a source of controversy. Lehman (1988) and Scavia et al. (1988) suggested that *B. cederstroemi* has reduced the densities of *Daphnia* in Lake Michigan. However, Sprules et al. (1990) reported no evidence of such a decline in their Lake Michigan data. Because investigations such as these are in their early stages, and because Great Lakes food webs may not yet have stabilized in response to the invader, the full impacts of *B. cederstroemi* on the Great Lakes may not be understood for some time.

The impacts of *B. cederstroemi* on Shield lakes will not be understood without research. Obvious initiatives which would

improve our understanding include studies of 1) the abundance, spatial distribution, migratory behaviour, production and life history of *B. cederstroemi* populations in several Shield lakes with differing fish assemblages, 2) the interaction of *B. cederstroemi* with other large, planktonic macro-invertebrate predators in Shield lakes, including mysids, mites, larval Chaoborus, and *Leptodora*, 3) prey preferences of *B. cederstroemi* in Shield lakes, 4) predation rates of *B. cederstroemi* and production rates of their preferred prey, and 5) the spread of *B. cederstroemi* across the Shield. Little or no historical zooplankton data exist for the vast majority of Shield lakes that will ultimately be colonized by *B. cederstroemi*. Therefore, paleolimnological assessments of changes in zooplankton assemblages may also be a fruitful avenue of research for such lakes (eg. Kitchell and Kitchell 1980).

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Table 1: Summary of selected data on the location and morphometry of the study lakes, on the sampling protocol for B. cederstroemi, and on the abundance of B. cederstroemi in the study lakes. The latitude (Lat), longitude (Long), lake area and elevation (Elev) are provided, followed by the year of sampling (Year), the number of stations visited in the year (NS), and the number of dates (ND) all stations were visited. The gear code (GC) and sampling protocol code (SC)* are indicated. B. cederstroemi data summarized include the average detection limit (DL) for all stations and dates calculated assuming 1 B. cederstroemi was observed in each sample. The percent of samples in which B. cederstroemi was observed is listed (Occ), as is the total number of animals observed (Total Num) in the year. Finally the range in abundances of samples with B. cederstroemi is given along with the number of the months in which it was observed (1-January, 2-February, etc.).

											Bythotrephes data				
Lake	Lat	Long	Area (ha)	Elev (m)	Year	NS	ND	GC	SC	mean DL (#/m³)	Occ (%)	Total Num	Range in abundance (#/m³)	Month Num	Number of Cottages
Fairy	4520	7911	712	284	1990	9	1	2	2	0.88	56	19	1.02-7.8	8	136
					1991	3	1	2	2	0.72	67	64	4.39-25.1	6	
Go Home	4501	7953	666	180	1991	5	1	2	2	0.56	20	2	3.05	6	433
Joseph	4510	7944	5156	225	1989	7	7	1	1	1.89	6	2	0.85-2.86	6,7	792
					1990	9	6	1	1	1.36	5	3	0.35-0.73	7,9	
Kawagama	4518	7845	2914	355	1990	7	1	2	2	0.89	0				900
Lake of Bays	4515	7900	7058	315	1990	12	1	2	2	0.72	0				1784
Mary	4515	7915	1065	281	1990	7	1	2	2	1.59	67	11	0.89-5.5	7	248
Muskoka	4500	7925	12206	225	1989	9	5	1	1	2.68	29	33	1.8-11.8	6,7,8,10	3986
					1990	11	5	1	1	1.74	14	8	0.48-1.9	6,7	
Peninsula	4520	7907	865	284	1990	2	1	2	2	0.61	0				313
					1991	2	1	2	2	0.51	0				
					1991	1	1	3	3		100	11	2.33	6	
Rosseau	4510	7944	6374	226	1989	7	5	1	1	3.26	14	8	1.17-6.5	7,9,10	907
					1990	10	6	1	1	2.05	18	11	0.29-17.5	6,7,8,9,10	
Skeleton	4515	7927	2156	281	1990	3	1	2	2	0.9	0				348
Three Mile	4553	7916	929	247	1990	4	1	2	2	8.6	0				340
Vernon	4520	7917	1505	284	1990	2	1	2	2	0.66	0				337
					1991	1	1	2	2	0.35	0				
					1991	1	1	3	3		100	6	0.32	6	

* Gear Codes - 1: 76 µm mesh, 11.5 or 13 cm diameter, un-metered, conical tow net
2: 150 µm mesh, 46 cm diameter, metered, conical tow net
3: 500 µm mesh, 47.5 cm diameter, metered, closing, conical tow net

Sampling Codes - 1: pooled triplicate vertical hauls from 0.5 m above bottom
2: single vertical haul from 30 m, or from 2 m above bottom if the station was <30 m deep
3: horizontal haul at the lake surface